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Navy Clothing & Textile Research Facility (NCTRF) conducted tests of second generation models of experimental prototypes which proved superior to the Navy standard in all dexterities and equal in low-temperature environments (-40°F for 2 hours). The best candidate prototype (Type IV, Mod 3) was selected and a limited number were constructed for field tests at various Alaskan military sites. Test subjects, engaged in a variety of duties involving manual dexterity rated the experimental glove (Type IV, Mod 3) superior to the standard Navy handwear in all dexterities but less protective at -40°F for extended periods of

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time (4 hours). A single drawback was that the experimental glove, utilizing a polyurethane foam liner, absorbed excessive moisture (perspiration and melting snow), thus representing a potentially serious hazard. Changes were made to incorporate a moisture barrier lining (Mod 4) and NCTRF conducted in-house tests to ascertain the effect on both low-temperature and manipulatory capabilities. (U)

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LOW-TEMPERATURE HANDWEAR WITH IMPROVED DEXTERITY
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PART I: Background and Review

The broadening scope of Navy operational responsibilities over the past two decades has resulted in changes of "in-action" functions and equipment including reduction of dimensions of weapons systems components. These changes have placed growing reliance on positive and expanded manual functionability at all extremes of climatic stress. The effect has been growing objection to the lack of tactile discrimination and dexterity experienced by personnel wearing the Standard Mittens, Extreme Cold Weather, Impermeable (Figure 1). Although this item has historically supplied maximum protection against extreme cold and cold/wet conditions for all personnel, the standard glove now appears inadequate, because it fails to give needed dexterity to perform the vastly increased duties of personnel in these environments.

The Navy Clothing and Textile Research Facility (NCTRF) program of handwear development was directed at re-evaluation of the original rigid protective requirements and at effecting, if possible, some compromise of protection to achieve significant improvement of hand functional parameters.

Through a literature search, NCTRF established pertinent details contributing to the most effective functioning of the bare hand. Particular attention was directed to the relevance of thumb articulation. We wanted to know how the thumb functioned in assuming positions required for effective grasping and pinching; how it attained its best gripping position; and how the unrestricted thumb worked in opposition to the finger phalanxes. Data bearing on the order of strength of the fingers operating singly and in unison established areas of serious consideration.

The efficacy of overall and equal handwear insulation was re-examined against actual protection required at primary hand sites. It was evident that the dense, tough, palmar skin with its variant callous areas, uniquely layered composite of muscle and low-reaction receptor nerves, required a minimal protective insulating layer.

The objective of our program was to improve tactility and allow the dynamic digits to function with reduced hindrance. NCTRF developed test panels and devices to establish a means of numerically evaluating a variety of dexterities comparing the standard and the experimental glove configuration with the bare hand. Tests were designed to show changes in ability to perform tasks requiring dexterities comparable to those required aboard ship. Thus, the ability to perform manual tasks was the only parameter measured in the initial test phase.

Since we were looking for small differences, the results of these dexterity tests (Tables I to IV of Reference 1) involving 10 subjects were impressive in that each experimental configuration proved superior to the Standard, and Type IV Mod 1 prototype (Figure 2) approached bare-hand

capabilities in certain dexterities (Tables III & IV of Reference 1).

MOD 2 PROTOTYPE DESIGN

Review of data, developed by Reference 1, resulted in selection of Types II Mod 1 (Figure 3) and IV Mod 1 (Figure 2) configurations to be further modified for an additional laboratory evaluation that would involve monitoring of skin temperatures at specific hand sites while dexterities were performed at $0^{o}F$, $-20^{o}F$ and $-40^{o}F$ for up to 2 hours. These selections were based on evaluations of test subject comments and measured dexterities (Figures VII through XVI of Reference 1).

Clo value tests on the Mod 1 prototypes were obtained too late to contribute to the construction of Mod 2 items. However, they were significant and indicated that the volar surfaces had adequate protection with a 1/8" foam while the dorsum had somewhat lower clo values and could benefit from more than 1/4" foam insulation.

The following data indicate the protective capabilities of both the Navy Standard and the experimental handwear.

(1) Hand calorimeter evaluations on the thermal insulation of experimental handwear (configured to improve manipulatory capabilities) compared to the Navy Standard Cold Weather Mitten have been completed.

(2) The following five mittens, including the Navy Standard Cold Weather mitten and four experimental mittens with various finger configurations, were evaluated:

(a) Navy Standard - Mitten configuration consisting of an outer and inner shell of chloroprene-coated nylon and a knitted nylon fleece interlining.

(b) Experimental Type I Mod 1 - Trigger-finger configuration consisting of a PVC-dipped outer shell on a knitted cotton base and an inner shell with a 3/32" urethane foam palm and a 1/4" urethane foam back.

(c) Experimental Type II Mod 1 - Trigger finger configuration consisting of a PVC-dipped outer shell on a knitted cotton base and an inner shell of 1/8" urethane foam on the palm and a 1/4" urethane foam on the back.

(d) Experimental Type III Mod 1 - A three-compartment configuration consisting of a PVC-dipped outer shell on a knitted cotton back and an inner shell of a 3/32" urethane foam palm and a 1/4" urethane foam back.

(e) Experimental Type IV Mod 1 - A four-compartment configuration consisting of a PVC-dipped outer shell on a knitted cotton back and an inner shell of a 3/32" urethane foam on the palm and a 1/4" urethane foam on the back.

(3) The average sectional and overall clo values are represented in Table I and Figure 4. The sites on which specific values were requested were:

(a) Volar Surface of the hand over the third metacarpal - (Sec. 11)

(b) Dorsum of the hand over the third metacarpal - (Sec.12)

(c) Distal phalanx of the third finger, volar surface - (Sec. 6)

(d) Distal phalanx of the fifth finger, outer surface - (Sec. 10)

The measured insulation values relate to the insulation (and configuration) as follows:

Sec. #	6	10	11	12	Overall
Standard	1.32	0.66	1.83	1.49	1.02
Type I Mod 1	0.81	0.62	1.76	1.48	0.94
Type II Mod 1	0.79	0.74	1.55	1.53	0.87
Type III Mod 1	0.74	0.52	1.54	1.23	0.79
Type IV Mod 1	0.48	0.56	1.49	1.15	0.79

Obviously, none of the four experimental gloves provided as much thermal insulation as the standard glove. Of the two gloves in which the 3/32" foam was used in the palm (Types I and IV), Type I provided better insulation for all four sections than Type IV.* When the 1/8"foam was used in the palm (Types II and III), Type II gave better insulation for all four sections than Type IV. Of the four experimental gloves, Type I was best overall, but in only two of the four specified areas, the dorsum of the hand and, marginally, the third finger.

Although the above results indicated that increased protection was required for all four experimental configurations, these results were arrived at subsequent to preparation of the Mod 2 procurement. Therefore a 1/4" foam thickness was retained on the dorsum, and the volar surface continued with 1/8" foam based on results of dexterity tests.

*The Type I as a "mitten" potentially offered better protection than the Type IV which had four compartments.

Table I. Clo Value Tests

Section	Hand No Glove	Navy Std.	Navy Exp. Type I	Navy Exp. Type II	Navy Exp. Type III	Navy Exp. Type IV
1	0.32	0.90	0.77	0.55	0.56	0.55
2	0.47	0.71	0.81	0.64	0.66	0.66
3	0.38	0.64	0.58	0.48	0.54	0.43
4	0.25	1.36	0.68	0.48	1.08	0.48
5	0.47	1.59	0.86	0.94	0.88	0.57
6	0.24	1.32	0.81	0.79	0.74	0.48
7	0.23	1.26	1.19	1.05	0.61	0.61
8	0.38	1.43	1.23	1.02	0.63	0.73
9	0.41	1.82	2.02	1.93	1.47	1.40
10	0.24	0.66	0.62	0.74	0.52	0.56
11	0.46	1.83	1.76	1.55	1.54	1.49
12	0.70	1.49	1.48	1.53	1.23	1.15
I	0.38	0.97	0.97	0.83	0.93	0.82
II	0.33	1.02	0.72	0.62	1.07	0.58
III	0.49	1.28	1.08	0.97	1.31	0.99
IV	0.35	1.66	1.24	1.17	1.05	0.67
V	0.47	1.84	1.54	1.51	1.37	1.18
VI	0.37	1.91	1.85	1.85	1.13	1.12
VII	0.55	1.87	1.98	2.19	1.52	1.46
VIII	0.30	0.98	0.94	1.09	0.81	0.77
IX	0.39	1.26	1.19	1.34	1.09	1.10
X	0.34	0.80	0.81	0.75	0.75	0.74
OVERALL	0.37	1.02	0.94	0.87	0.83	0.79

The Mod 2 prototype configurations were designed to contain adduct thumb stalls as in commercial practices. The objective was to compare dexterities of the adduct thumb positioned in a median axis to the palm against those of the Mod 1 thumb stalls which were abduct and positioned coincident with the plane of the palm. (Figures 5 and 6 show comparisons of Type II Mod 1 and 2 and Type IV Mod 1 and 2 thumb stalls.)

During the course of this investigation, representatives of the Supervisor of Diving, Naval Sea Systems Command, aware of severe manipulatory constraints and limited cold stress protection (under water) of the Standard Divers Mitten asked if we would produce several insulated, long gauntlet, trigger-finger gloves similar to the Type I Mod 1 prototype. The selection was primarily one of SUPDIVE preference. For purposes of this program, Type II Mod 2 and Type IV Mod 2 are the continuing candidate prototypes.

GENERAL DESCRIPTION OF MOD 2 PROTOTYPE

Outer Shell

The outer shell for each type was a dipped neoprene coating on an interlocking flexible cotton base fabric. The coating was waterproof, possessing good low temperature ($-30^{o}F$) characteristics and a roughened, skid-resistant palmar surface accomplished by an overdip method.

Joining Shells

The inner insulating shells used 1/8" polyurethane foam on the palm and finger facings and 1/4" polyurethane foam on the dorsum surface and were permanently secured to the outer shell at the finger edges and along the cuff edge of the finished gloves. The outer shells were folded over the inner and secured to minimize exposure to edge abrasion of the insulating foam.

Type II Mod 2 Handwear Configuration

Type II Mod 2 (Figure 7) was generally contoured as a "trigger-finger" type mitten. It contained one adduct thumb stall, a second finger stall. and a large third stall for the third, fourth and fifth fingers, proportionally contoured along the top edge to accommodate the varied finger lengths.

The lining shell was expanded polyurethane foam, laminated to a nylon tricot on the innermost surfaces. The inside face of the foam was coated to resist water penetration. It had good resistance to low temperature, aging and compression set. Its moisture absorption was low and in its finished state possessed good compression strength.

Type IV Mod 2 Handwear Configuration

Type IV Mod 2 (Figure 8) was designed to supply four finger stalls. The thumb stall was adduct and separate stalls were supplied for the second and third fingers. The larger, fourth stall was proportionally contoured

along the top edge to contain the fourth and fifth fingers. The inside lining structure was the same as Type II Mod 2.

Type I Mod 2 Divers' Glove Configuration

Type I Mod 2 (Figure 9) followed the general outline of a standard trigger-finger configuration. It was designed to fit snugly to the hand to eliminate hard folds and creases caused by water pressure at operating depths. A close-fitting gauntlet was added, making the overall length of the glove 17 1/4". Double take-up straps were located on the gauntlet to hold the glove securely against the rubber sleeve cuff of the Divers, Dress.

Part II: Physiological/Kinesiological Testing of Type II Mod 2 and Type IV Mod 2

Previous tests (1) indicated that the Navy Standard extreme-cold weather handwear limited manual dexterities to the point that it has proven generally unacceptable. Screening tests conducted as reported (1) indicated that improved dexterity could be obtained by using more modern materials, designs and methods of fabrication. Hand skin temperatures (HST) were not monitored in these screening tests; however, improvements in design of the most promising prototype were made and these tests were run to compare performance of the improved prototypes of Type II Mod 2 and Type IV Mod 2 handwear previously described (1). HST were also monitored on test subjects wearing the improved models at temperatures of 0, -20 and -40°F while dexterity tests were conducted using the same tests as before.

PROCEDURE

Thermocouples were placed as indicated (Figure 10) and hand skin temperatures were recorded while test subjects performed the dexterity tests previously described. HST were looked at in several ways, but averaging all the HST and omitting the forearm and back of hand temperature seemed to present a picture of overall response compatible with that seen when responses of each temperature probe position are plotted separately.

CLOTHING

Clothing worn at all temperatures was the Army Extreme Cold Weather Clothing System supplied by the U.S. Army Natick Research and Development Command. All test subjects were issued identical clothing and wore whatever of it they felt to be necessary to keep them warm during tests.

Handwear was issued on a random basis and was worn so that each test subject wore each item at least three different times while performing the dexterity tests at given temperatures.

RESULTS

Results of the dexterity tests duplicated those results reported previously. These tests were carried out at extreme cold temperatures and it was expected that there would be a decrease in performance at the colder temperature. However, the only item consistently showing a significant decrement was the Navy Standard Extreme Cold Weather handwear. Conditions were not extreme enough at -40°F for the other items to demonstrate any decrement in performance (Figures 11, 12, 13).

Test results show (Table II) that any one of the improved prototype items allowed better performance of assigned tasks and gave equivalent or better protection from cold temperature than the Navy Standard used as comparison. Differences among the prototypes were not statistically significant, but Type II Mod 2 gave better thermal protection while allowing dexterity almost equivalent to Type IV Mod 2.

Any of the prototype handwear afforded thermal protection equivalent to or better than the Navy Standard while allowing greatly increased manual dexterity. A trend without statistical significance indicated that the Type II Mod 2 prototype maintained a slightly higher HST. Since measured dexterities were statistically equivalent among the prototypes, the trend toward a slight decrement of dexterity in Type II could be significant as added protection under extreme conditions. Type IV could be considered if the slightly greater dexterity was a prime factor.

Table II. Average Hand/Skin Temperature

	0°		-20°		-40°	
Type	%	SDEV	%	SDEV	%	SDEV
Standard	38.5	±11	44.3	±11	46.4	±12
Type II	44.4	±13	37.4	±11	41.6	±10
Type IV	37.2	±14	44.0	±10	50.5	±17
Exp. Sub. Mitt	37.0	±10	44.3	±13	42.4	±10

Percent change in average of skin temperature probes from 0 time to end of test. Temperatures from back of hand and forearm were so nearly constant in all cases that they were omitted from these calculations.

A Continuation of Physiological Evaluation of Cold-Weather Handwear

Introduction

This series of tests was designed to show whether or not there is a significant difference in the positioning of the thumb on Model 1 (thumb abduct) and Model 2 (thumb adduct) experimental cold-weather handwear while a variety of dexterity tests are performed. There are indications from previous tests that the thumb position creates a dexterity differential great enough to warrant further studies. NCTRF used the Block Packing Test, the Minnesota Rate of Manipulation Test, two handed placement, and the Hand-Tool Dexterity Test.

Practice runs in each test were made until the time difference for performance was five seconds or less. At this point we assumed that the learning curve had plateaued and timed tests were recorded.

Tests were administered in the manner described for each test and there was a 1-to-3-minute rest period between tests. Tests were run at least five times under the conditions set for each test subject and for each set of handwear.

Test Conditions

Temperature of $0^{O}F$ ONLY

Wind speed of 3 to 5 MPH

Time of Tests

30 Minutes for dressing

6 Hours for actual test

30 Minutes for undressing

There was no preliminary testing before the actual tests began.

Number of Gloves to be Tested

Two pairs of Experimental Type II, Mod 1 and 2

Mod 1 with thumb in an abduct position

Mod 2 with thumb in an adduct position

Clothing

Extreme-cold-weather clothing, except for handwear, was supplied by U.S. Army Natick Research and Development Command Chambers and was whatever the test subjects considered necessary for body comfort at the temperature at which the tests were run.

Parameters Monitored

These tests were designed to evaluate dexterities only. No body temperatures were used.

Description of Tests

All tests were conducted in the NCTRF Climatic Test Chambers. Test subjects were volunteers from the U.S. Army Natick Research and Development Command test subject pool. Prior to the test, test subjects received a thorough physical examination and were certified by the Clinic Medical Officer as being physically fit for the type of duty involved.

Minnesota Rate of Manipulation Test

The test consisted of picking up circular metal blocks, turning them over, and placing them in holes in a metal frame. Performance was determined by the number of blocks moved in 30 seconds.

Block Packing Test

The test was performed by holding an 8" x 8" x 6" box in one hand and packing as many 1" x 1" x 1" wooden blocks as possible into the box using the free hand. Performance was measured by the number of blocks packed in 30 seconds.

Hand-Tool Dexterity Test

The Hand-Tool Dexterity Test consisted of removing nuts, bolts and washers of different sizes from one end of a metal frame and placing them in comparable holes in the other end of the frame. Tools used in this test were screwdrivers and open-end and adjustable wrenches of appropriate sizes. Performance was determined by total time lapsed to complete the task.

Results of all tests consisted of evaluation of the performance of the various tests, and opinions of the test subjects as to the comfort, ease with which tasks were accomplished, and personal opinions of the various types of handwear tested.

Objective data were statistically evaluated and preserved as means $\pm$ standard error. "T" values were used to determine significance of differences among the glove styles.

Dexterity Tests - Type II, Mod 1 (Thumb abduct) vs. Mod 2 (Thumb adduct)

Objective

Previous tests with the experimental cold-weather handwear, Mod 1 and Mod 2, indicated that the position of the thumb might make some difference in the ability of personnel to perform tasks requiring manual dexterity. This short series of tests was an attempt to elucidate this difference. At the time that this test plan evolved, no samples of the Type IV, Mod 1 or Mod 2 were available in pairs. Therefore Type II, the least dexterous of the experimental designs, was used for test purposes.

No attempt was made to measure hand and finger temperatures, as had been done previously. Also, these tests were run at $0^{o}F$, not as a cold stress, but to insure the comfort of the test subject while wearing these items and performing the dexterities tested.

Tests were performed as previously described and the following results tabulated:

(MRM) MINNESOTA RATE OF MANIPULATION TEST

Subj. No.	Type II Mod 1	Type II Mod 2	"t"	p	df	Result
	Mean ± Standard Deviation					
1	34.8 ±2.3	28.6 ±1.9	8.35	<.01	9	-
2	30.3 ±2.3	28.4 ±3.8	1.47	>.20	4	-
3	40.6 ±5.7	46.4 ±2.1	1.1214	>.3 <.2	9	+
4	34.4 ±3.6	44.0 ±2.4	6.00	< .01	4	+

(BPT) BLOCK PACKING TEST

1	18.7 ±1.6	20.4 ±1.8	8.35	<.01	9	+
2	23.2 ±2.3	18.8 ±1.9	1.47	>.20	4	-
3	19.8 ±2.2	19.2 ±1.2	.8620	<.5 >.4	9	-
4	20.2 ±.84	22.8 ±1.9	10.2283	<.01	4	+

(HTD) HAND-TOOL DEXTERITY TEST

1	604.0 ±34.1	534.6 ±55.1	4.549	<.02	4	-
2	593.8 ±32.5	574.8 ±67.4	1.3079	>.20	4	-
3	436.6 ±54.5	459.7 ±49.3	.6288	<.6 >.5	4	+
4	593.4 ±93.1	462.4 ±29.2	3.729	<.02 >.01	4	-

Comparison of the Mod 2 glove performance to performance wearing the Mod 1. "t" was derived by using "Student's "t" test.

Conclusion

As seen from the table, the results were inconclusive since test results were almost of equal statistical significance in each case. However, the mean "P" value was slightly in favor of the Mod 1 (Abduct thumb) glove--enough to weight a judgment in that direction though statistical evidence was insufficient to warrant a decision based on statistically provable differences.

Part III: General Construction Data and Limited Field Tests of Type IV Mod 3

CONSTRUCTION OF TYPE IV MOD 3 PROTOTYPE

Based on test evidence developed by Reference 1, as well as continued support of this evidence as noted in Part II, project personnel decided that a limited quantity of new prototype handwear be purchased and subjected to field use at military sites where low temperatures and manipulatory demands were normal daily occurrences. For such purpose Type IV Mod 2 candidate was selected for further modification in the areas of increased low-temperature protection and improved resistance to water absorption by the inner foam layers. Type II Mod 2 was eliminated as a candidate because of lower ratings in all dexterities tested. It was evident, however, that the fewer finger stalls of the Type II models contributed to a slightly higher hand skin temperature with less thickness of insulation. Type IV Mod 3 (Figure 14) was, therefore, planned to contain greater protective potential by an increase in polyurethane foam from 1/4" to 3/8" on the back of the hand, the fingers and the thumb and from 3/32" to 1/4" along the palm and finger facings. The configuration remained as in Model 2 with the thumb adduct since the results indicating greater manipulatory range of the abduct thumb had not been noted at this time.

One hundred pair of Type IV Mod 3 were requested (50 large, 50 medium) and these were to contain the following broad technical requirements.

1. <u>Experimental Forms</u>. Follow configurations, curvature and finger-stall placements of Type IV Mod 2. The shells shall be constructed of epoxy resin with aluminum powder as a filler.

2. <u>Insulating Liner Manufacturing Procedure</u>. The pattern shell shall be sprayed on the proper foam construction, and the parts cut and sewn together with the size tags installed in the proper positions. The foam insert shall then be placed inside the outer shell, hemmed, reinspected, and packaged by sizes.

3. <u>Outer Shell Compound</u>. The dip compound shall be a typical neoprene latex compound for low temperature (-40°F) resistance.

4. <u>Outer Shell Manufacturing Procedure</u>. The pattern shall be sprayed to the cotton knit fabric, sewn with tabs in the proper place and the seams turned to the inside. It shall then be loaded on the dipping form, dipped in the neoprene compound, cured, removed from the form, and inspected.

5. Insulating Liner Manufacturing Procedure. The pattern shall be sprayed on the proper foam construction, and the parts cut out and sewn together with the size tags installed in the correct positions. The foam inserts shall then be placed inside the outer shell, hemmed, reinspected, and packaged by sizes.

6. Material. The outer shell shall be all-cotton with a 38/1 interlock knit, unnapped; double carded yarns, having 29 courses and 37 wales per inch and weighing 4.8 oz./sq.yd., shall be used. The insulating liner shall be constructed so that the palm and finger facings will consist of nylon tricot laminated to 1/8" low-density polyurethane foam with a finished weight of 6.25 oz./sq.yd. The back of the hand, the fingers, and the thumb will consist of nylon tricot, laminated to 3/8" low-density polyurethane foam, with a finished weight of 9.0 oz./sq.yd.

LIMITED FIELD EVALUATION OF TYPE IV MOD 3 EXPERIMENTAL PROTOTYPE

Type IV Mod 3 prototypes were constructed by Edmont-Wilson Corporation for use in a limited field evaluation planned at several selected test sites. The object was to establish subjective reactions involving the dexterities, protection, general comfort and wear properties of the handwear compared with the standard Navy Extreme-Low-Temperature, Impermeable Mitt and any other standard handwear normally worn at the test site.

Questionnaires were composed containing inquiries that could be scored, as well as those of a more general nature requiring subjective responses. The evaluation encompassed a 90-day period ending in March 1974. (The field trials directed to the Antarctic Support Force personnel were conducted during the 90-day period from November 1973 through January 1974. Temperatures in that locale normally did not exceed -20°F during the months involved.)

Eighty pair of Type IV Mod 3 prototypes and an equal number of the Navy standard handwear were sent to four test sites. (Fifty percent of the handwear was sent to Antarctica and tests were concluded. Unfortunately the questionnaires were lost enroute to Christ Church, New Zealand.)

The test sites used were:

(1) Naval Reserve Facility, Anchorage, Alaska (from this point some items were forwarded to Elmendorf AFB, Ice Island T-3; Fort Greeley).

(2) Navy Alaskan Command Headquarters, APO, Seattle.

(3) HQ., U.S. Army Command (ARACD), Ft. Richardson, Alaska.

(4) U.S. Naval Support Force Antarctica, Quonset Point, Rhode Island (40 pair Type IV Mod 3; 40 pair Standard).

A total of 32 questionnaires were returned by June 1974 and the following tabulation represents a compilation of selected comments and information obtained from these sites. It must be noted that questionnaires 1-14 represent responses from Naval Reserve Facility, Anchorage; No. 15-22 from Elmendorf AFB, Ice Island T3, and Fort Greeley AFB; and No. 23-32 from HQ., U.S. Army Command (ARACD), Fort Richardson, Alaska.

TABULATION OF FIELD TEST DATA

The limited population of test data does not permit application of statistical techniques in analysis of results. The following summary and discussion are included in the report merely to indicate general trends evidenced by a very small number of field test subjects.

Dexterities

Question No. 4 - In comparison to your standard handwear, rate degree of restriction of Mod 3.

Less Binding	%	Same	%	More Binding	%	Total Responses
15	55.6	8	29.6	4	14.8	27

Question No. 7 - Did Mod 3 impart greater finger sensitivity than your standard handwear?

Yes	%	No	%	Total Responses
18	66.7	9	33.3	27

Question No. 10 - Did Mod 3 allow increase in speed of performance over your standard handwear?

Yes	%	No	%	Total Responses
19	70.4	8	29.6	27

Question No. 11 - Compare dexterity and manipulatory capabilities of Mod 3 against your standard handwear.

Better	%	Same	%	Poorer	%	Total Responses
15	55.6	7	25.9	5	18.5	27

Question No. 12 - Gripping characteristics of Mod 3 compared to your standard handwear?

Better	%	Same	%	Poorer	%	Total Responses
15	55.6	7	25.9	5	18.5	27

Question No. 21 - Compare ability to perform a variety of manual functions between Mod 3 and standard handwear.

Better	%	Same	%	Poorer	%	Total Responses
12	44.5	8	29.6	7	25.9	27

Question No. 8 - Did textured surface of Mod 3 afford resistance to slippage?

Excellent	%	Good	%	Poor	%	Total Responses
10	45.5	11	50.0	1	4.5	22

Comfort

Question No. 17 - Were hands warm at all times?

Yes	%	No	%	Total Responses
9	33.3	18	66.7	27

Question No. 18 - At what temperature (^{o}F) did hands become cold (hours)?

Never	Above 0^{o}F			Below 0^{o}F	
No. of Responses	No. of Responses	Avg.Temp.	Temp. Range	No. of Resp.	Avg.Temp.Range
10	2	20^{o}F	0^{o}-50^{o}	15	-37.7^{o}F 0^{o}-50^{o}

Question No. 19 - How long before hands became cold(hours at above temp.)?

No. of Responses	Hours (Average)
24	3.2

Question No. 20 - What was lowest temperature at which hands remained functional?

No. of Responses	Average ^{o}F	Range
27	-25^{o}F	20^{o} to -55^{o}

Question No. 20(a) - How many consecutive hours of exposure at that temp.?

No. of Responses	Average Hours Exposed	Range (Hours)
27	3.3	0.5 - 10.0

Question No. 5 - What was the lowest temperature (^{o}F) experienced (wearing Mod 3) during test?

No. of Responses	Average (^{o}F)	Range (^{o}F)
27	$-27^{o}F$	20^{o} to $-55^{o}F$

Question No. 5(a) - How long exposed to that temperature?

No. of Responses	Average Hours Exposure	Range
27	4.9	1.5 to 10

Question No. 5(b) - Were hands cold at that temperature? (Question 5)

Yes	%	No	%	Total Responses
11	40.7	16	59.3	27

Question No. 5(c) - Were hands too cold to perform duties? (At question 5 temperatures).

Yes	%	No	%	Total Responses
8	29.6	19	70.4	27

Question No. 5(d) - How long were you able to work after hands became cold (hours)?

Average in Hours	Range in Hours
1.5	1/4 to 6

Question No. 5(e) - How do Mod 3 gloves compare with your normal handwear in cold weather protection?

Better	%	Same	%	Worse	%	Total Responses
12	44.5	9	33.3	6	22.2	27

Question No. 6 - Did gloves become wet?

Yes	%	No	%	Total Responses
16	59.3	11	40.7	27

Question No. 7 - Did hands become wet?

Yes	%	No	%	Total Responses
20	74.1	7	25.9	27

Wear

Question No. 14 - How were wearing qualities of Mod 3 mitt?

Excellent	%	Adequate	%	Poor	%	Total Responses
17	63.0	8	29.6	2	7.4	27

Question No. 15 - Estimate work time in hours before wear was evident.

Response - No Wear	No Responses	Average Hours	Range of Hours
10	8	90 hours	2 to 400 hours

Question No. 16 - Where were areas of excessive wear located?

Area	Responses
16(a) Palm	5
16(b) Thumb Facing	6
16(c) Finger Facings	10
16(d) Back of Hand	1
16(e) Back of Thumb	1

DISCUSSION OF FINDINGS

Dexterities

In questions dealing with lack of restriction, sensitivity, speed of performance, dexterity and manipulatory capabilities, and gripping, the Type IV Mod 3 prototype was considered superior in a range of 55.6% to 70.4%. In these criteria the percentage of subjects that considered the Mod 3 less acceptable than the Navy Standard Mitt ranged from 14.8% to 33.3%. The general trend, therefore, indicates that manipulatory capabilities and dexterities were substantially improved when the experimental prototype was worn.

Comfort

The minimum temperature experienced while at sea rarely falls below $-20^{o}F$. That level of protection combined with a 4-hour maximum exposure

time, therefore, was the target for the new prototype handwear. The general trend, throughout this segment of the survey, strongly indicates the capability of meeting this objective with the present disposition of insulation. Questions 5, 5a, 5b, and 5c combined indicate that, at an average temperature of -27°F for nearly 5 hours, approximately 60% of the test subjects did not feel cold and 70% were not too cold to perform their normal duties.

The temperatures experienced during this test exceeded the environmental stress limits for this handwear. Although such results as -50°F exposure for 10 hours were recorded, in the main, temperatures below -30°F did cause discomfort. A notable shortcoming was the frequent statement that subjects did experience cold when working with metal tools or equipment. The low compression resistance of the thin (1/4") layer of polyurethane foam in the palmar areas became a conductor when a fair degree of pressure was introduced. The use of a five-finger anti-contact glove insert could reduce this potential hazard.

In 59.3% of the cases the insulating liner became wet from a combination of snow entering at the cuff and absorption of perspiration. Although most of these subjects did not experience sensations of cold while hands were functioning, the mere possibility of frostbite during any period of low activity is a serious bar to total approval of the Mod 3 glove.

Wear

The span of hours worked averaged 90 hours (2-to-400-hour range) and cannot be considered relevant; however, the degree of wear or breakdown was insignificant and did indicate that this factor did not represent a serious problem.

Part IV: Conclusion and Recommendations

The Type IV Mod 1 prototype proved the superior model in approaching the kinesiological parameter experienced when using bare hands. However, both the Navy and Army physiological evaluations indicated the need for increased protection. To that direction the 3/32" polyurethane foam thickness on the back of the hand was increased to 1/4" and the palm surface retained a 1/8" thickness.

The resultant Type IV Mod 2 also contained an abduct thumb stall lying on a horizontal plane of the hand. Tests for the various dexterities supported this change in thumb placement, and digital functionability in this glove was dramatically higher and of greater dexterity than in the standard Navy Extreme Cold Weather Handwear. However, the Army (ARIEM) tests had indicated that a still greater insulating thickness was essential for adequate protection, and the Type IV Mod 3 evolved containing a 3/8" layer of polyurethane at the back and a 1/4" layer at the palm and finger facings.

The third generation Type IV was subjected to limited field trials at a variety of land-based military stations located in Alaska. Test personnel included ice and water handlers, fuel handlers, field technicians employing various measuring devices, weapons and ammunition handlers, equipment maintenance and operating personnel. Responses showed that the Type IV manipulatory capabilities far exceeded those of the standard Navy handwear. The low temperature capabilities were well within the -20°F, 4-hour parameter required for this item and the wear properties appeared adequate and could, if necessary, be improved by increasing the thickness of the outer cover of neoprene latex.

However, the accumulation of moisture within the polyurethane foam layers and the resultant hazard potential indicate that a fourth generation prototype of Type IV should be constructed utilizing a moisture barrier film enveloping the polyurethane.

APPENDIX A. ILLUSTRATIONS

Figure 1. Standard Navy Extreme-Cold-Weather Mitt.

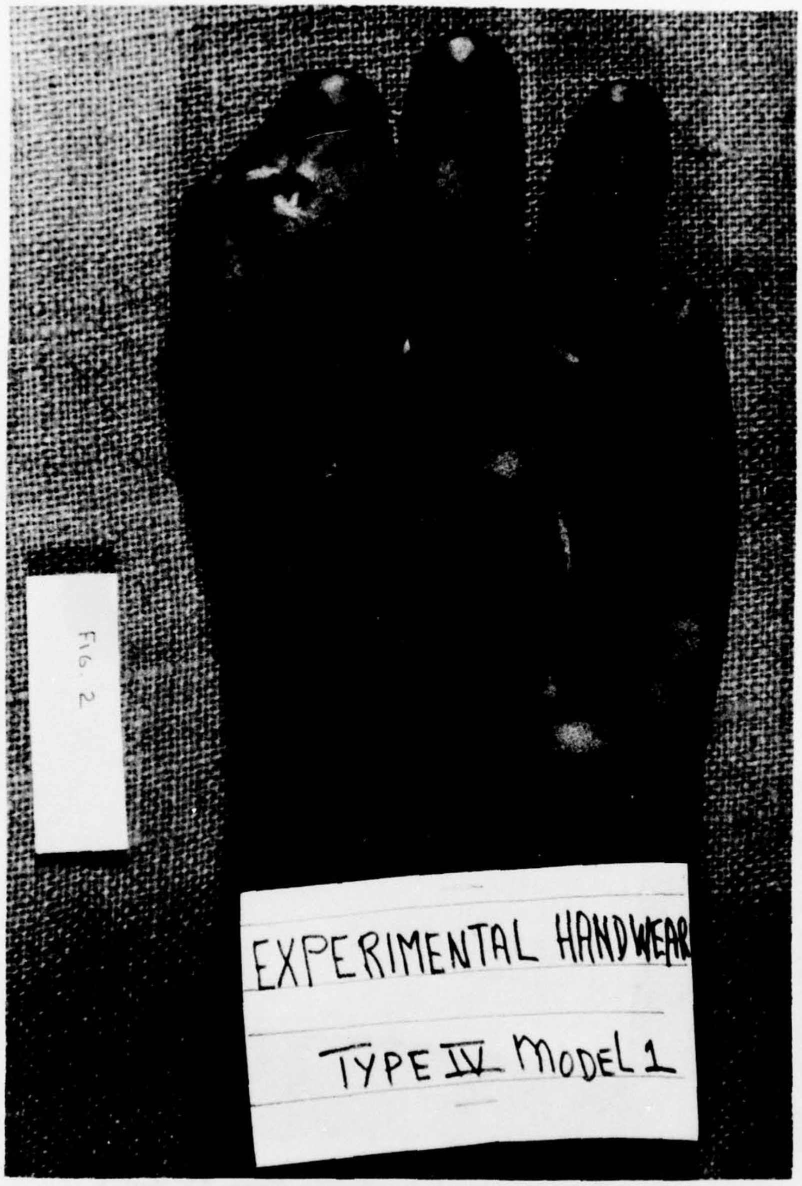

Figure 2. Experimental Handwear Type IV Mod 1.

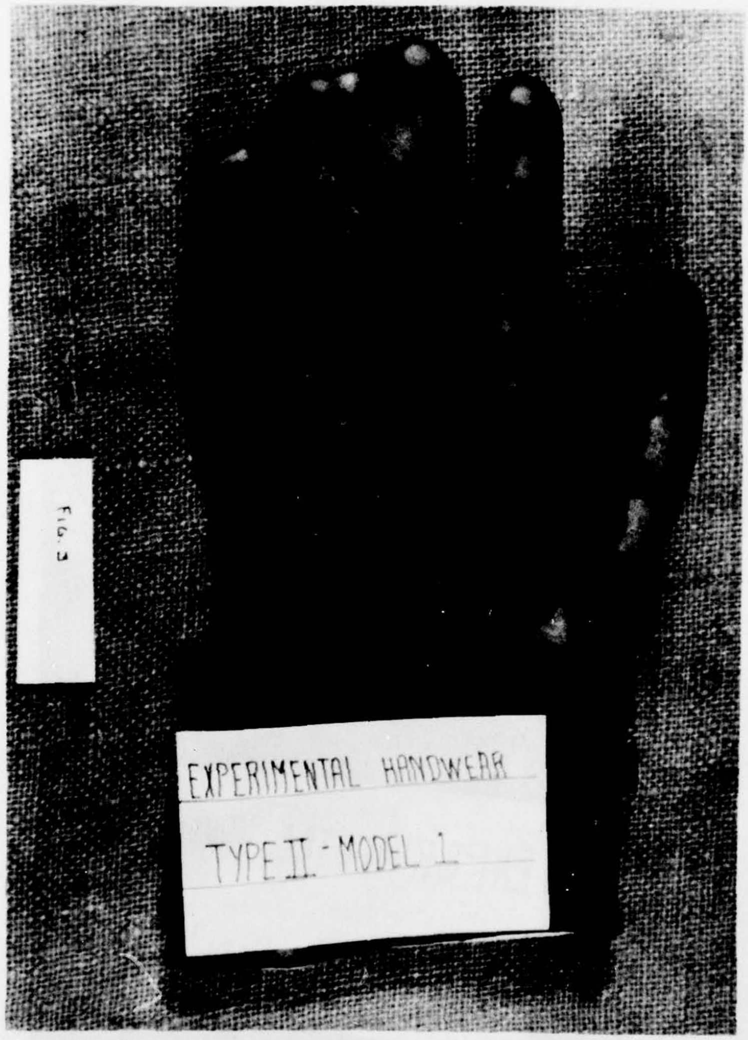

Figure 3. Experimental Handwear Type II Mod I.

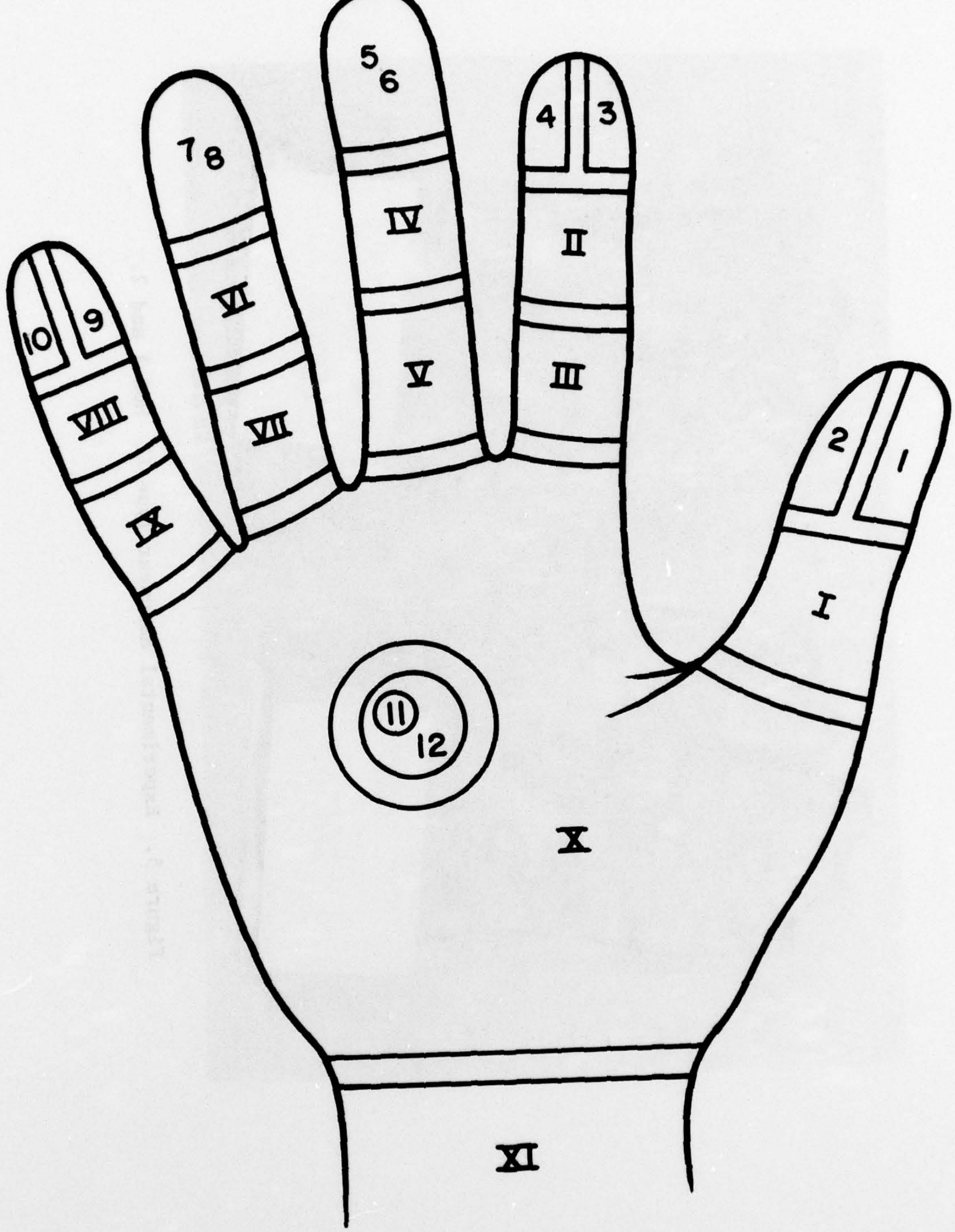

Figure 4. Thermocouple Placement on Hand.

Figure 5. Experimental Handwear Type II Mod 1 and 2.

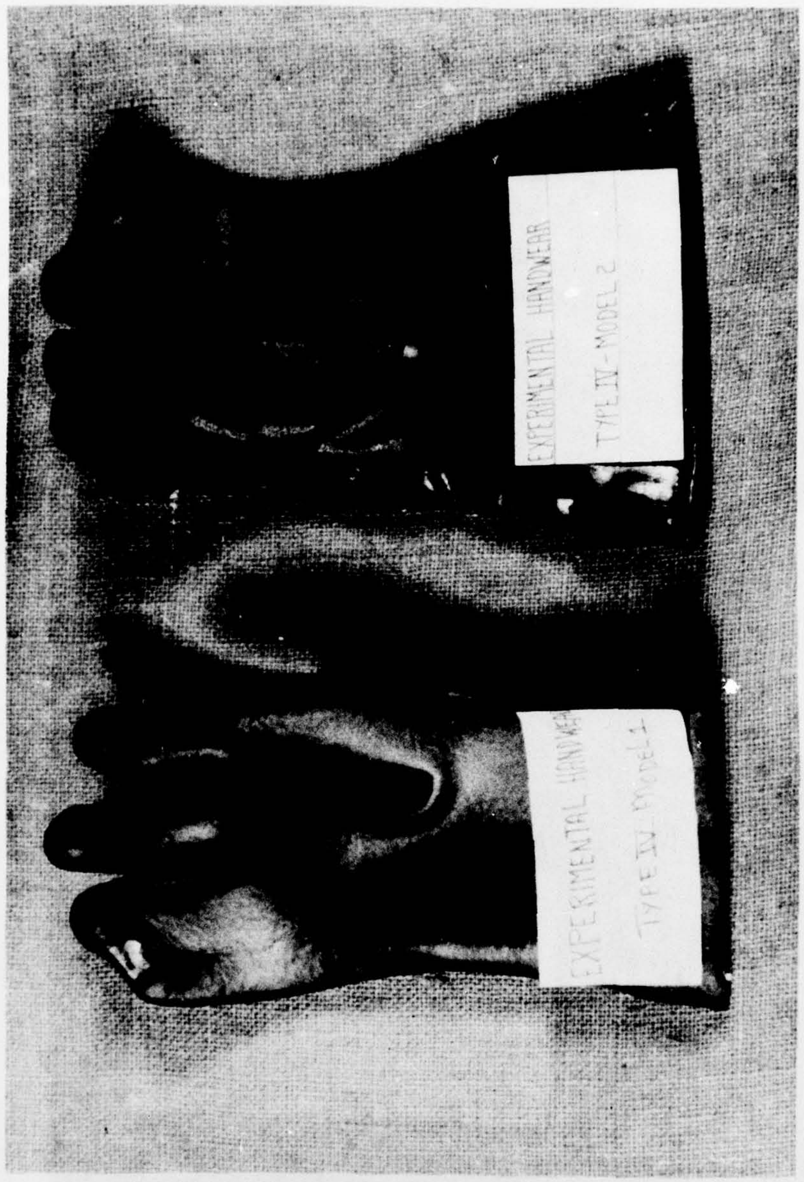

Figure 6. Experimental Handwear Type IV Mod 1 and 2.

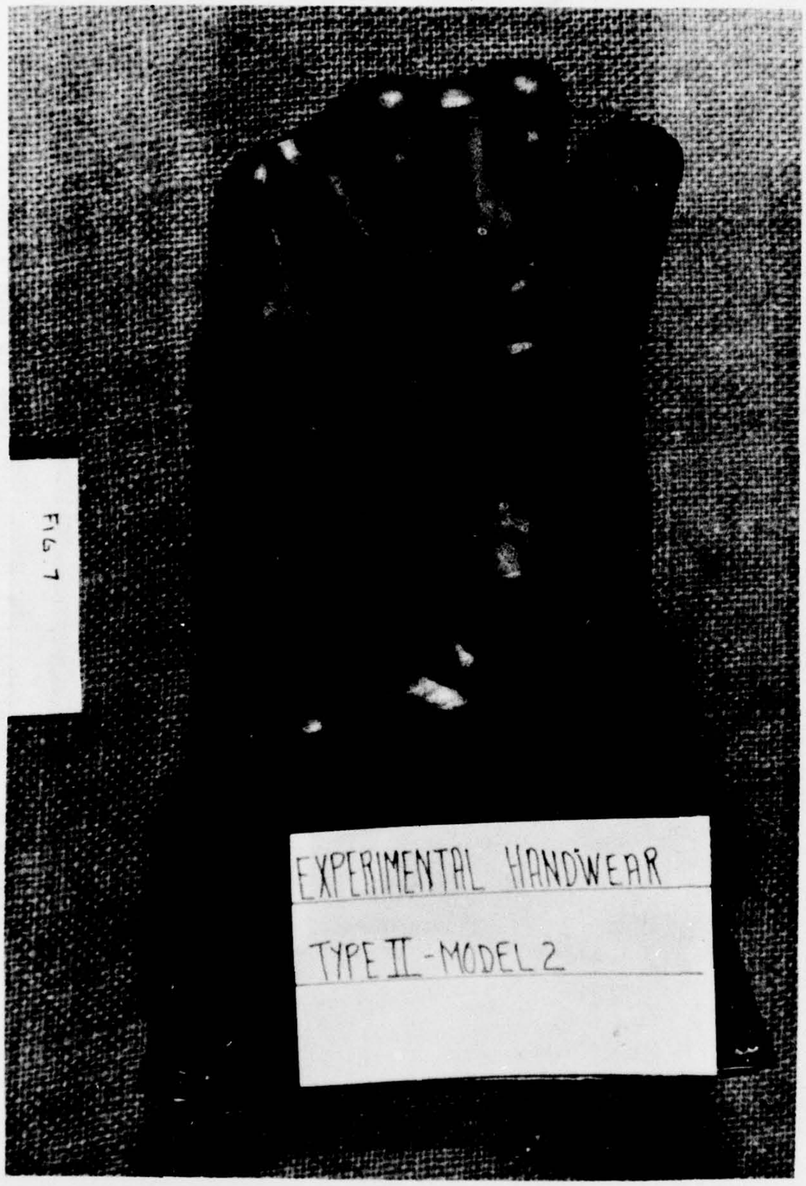

Figure 7. Experimental Handwear Type II Mod 2.

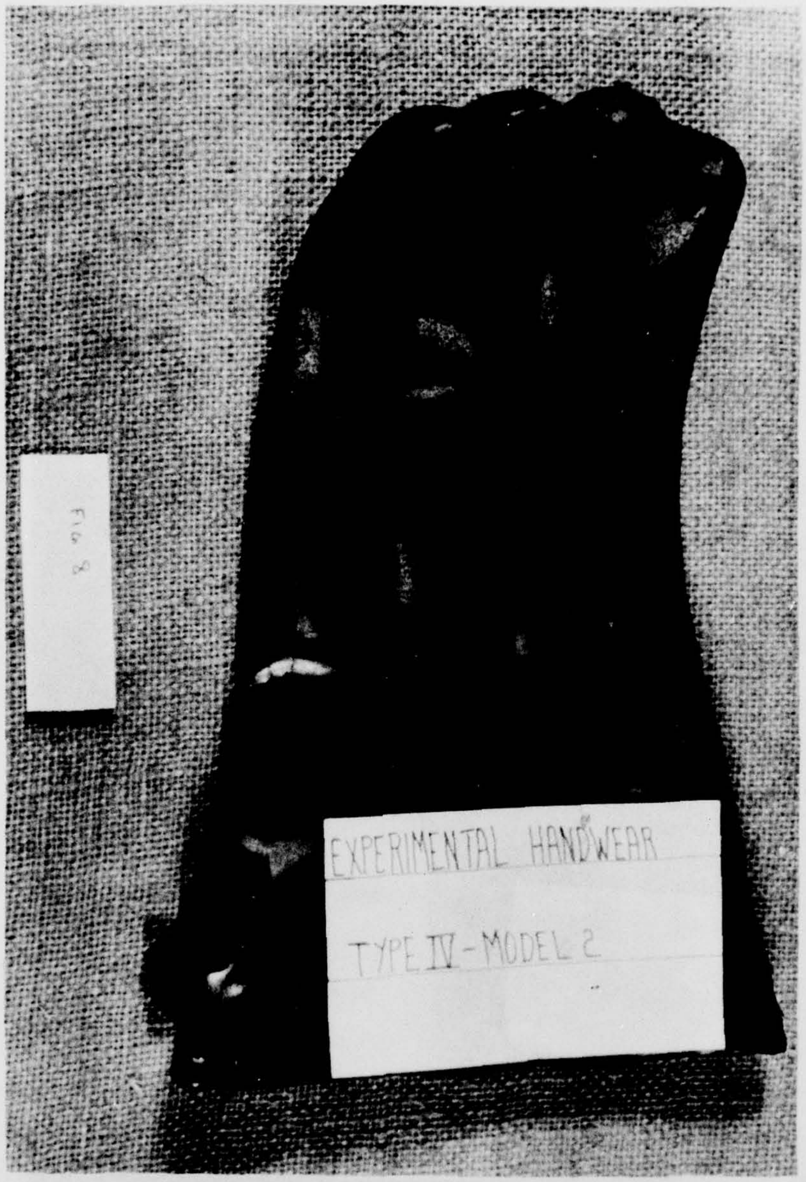

Figure 8. Experimental Handwear Type IV Mod 2.

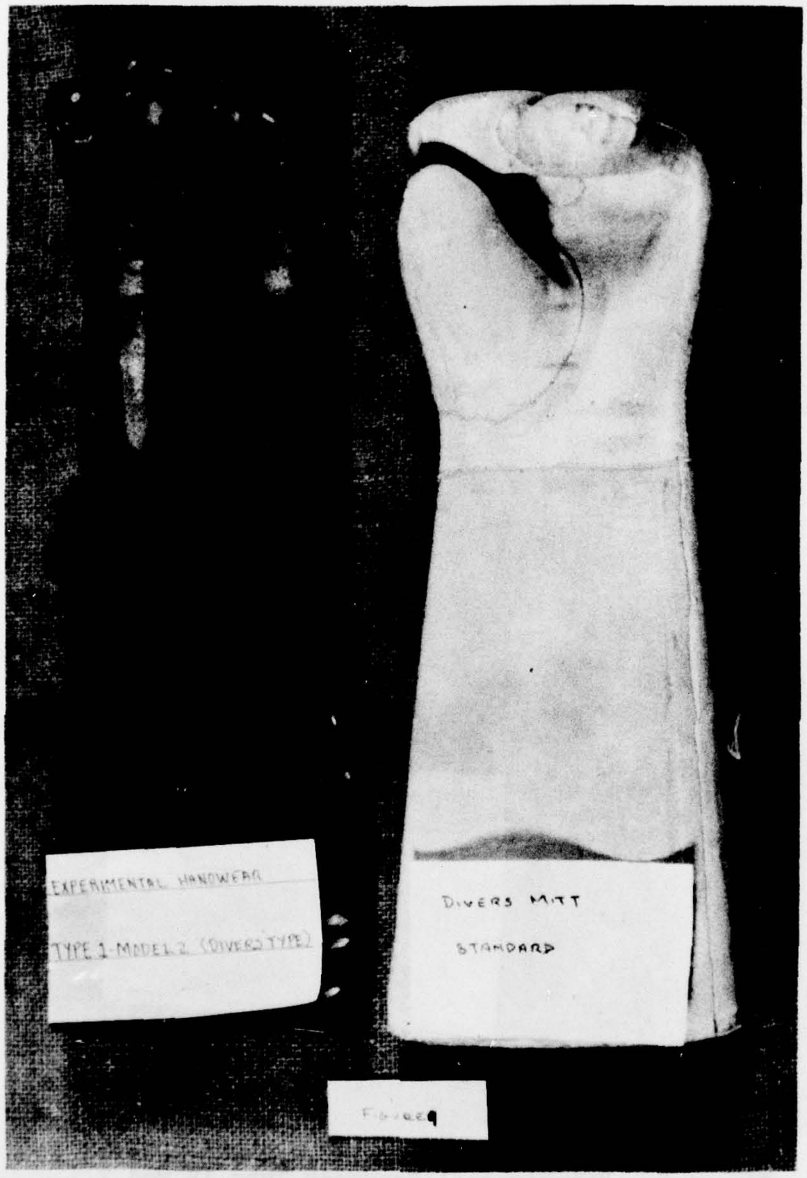

Figure 9. Experimental Handwear Type I Mod 2 (Diver's Type) and Standard Diver's Mitt.

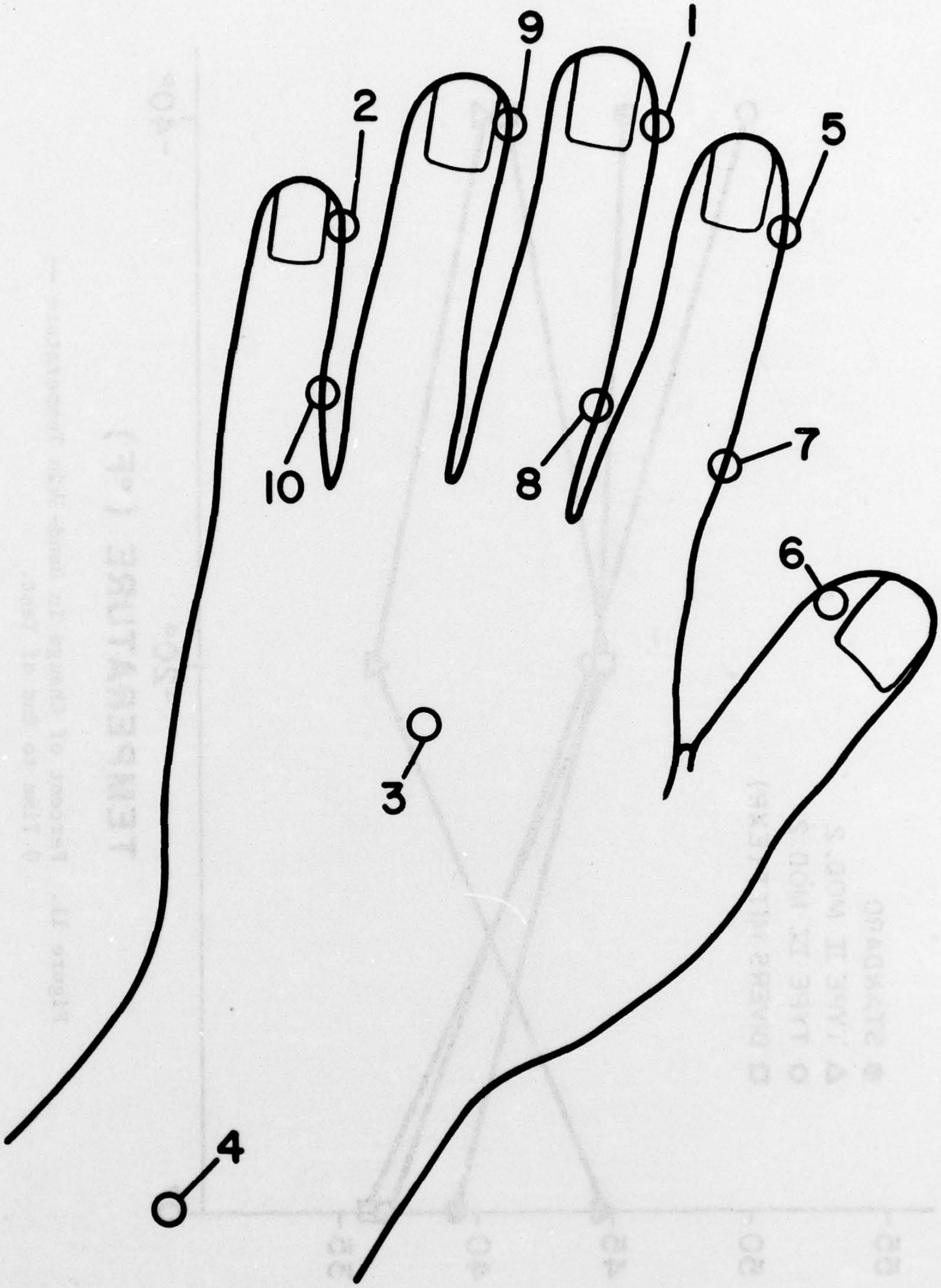

Figure 10. Position of Temperature Sensors.

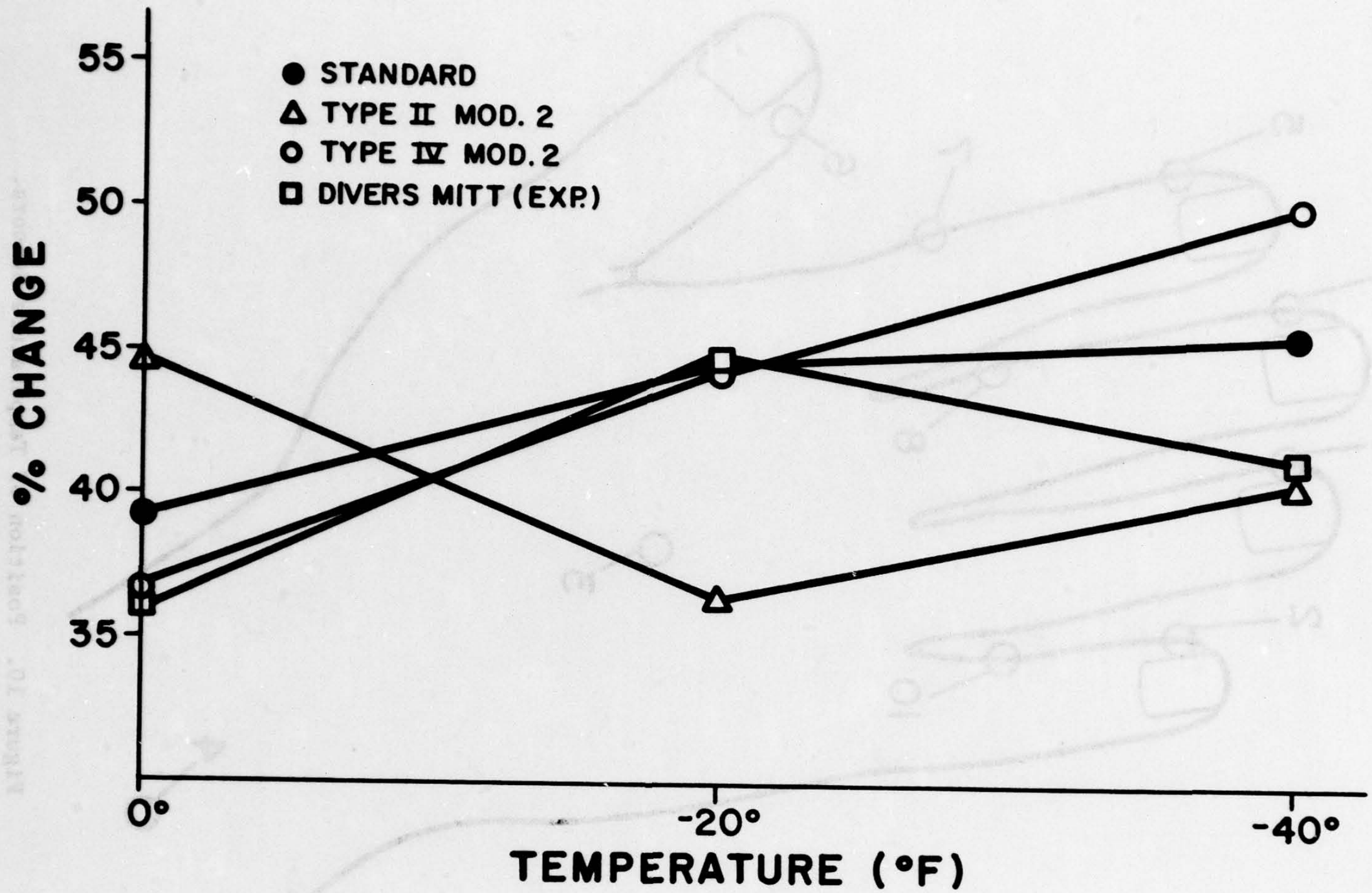

Figure 11. Percent of Change in Hand-Skin Temperature -- 0 Time to End of Test.

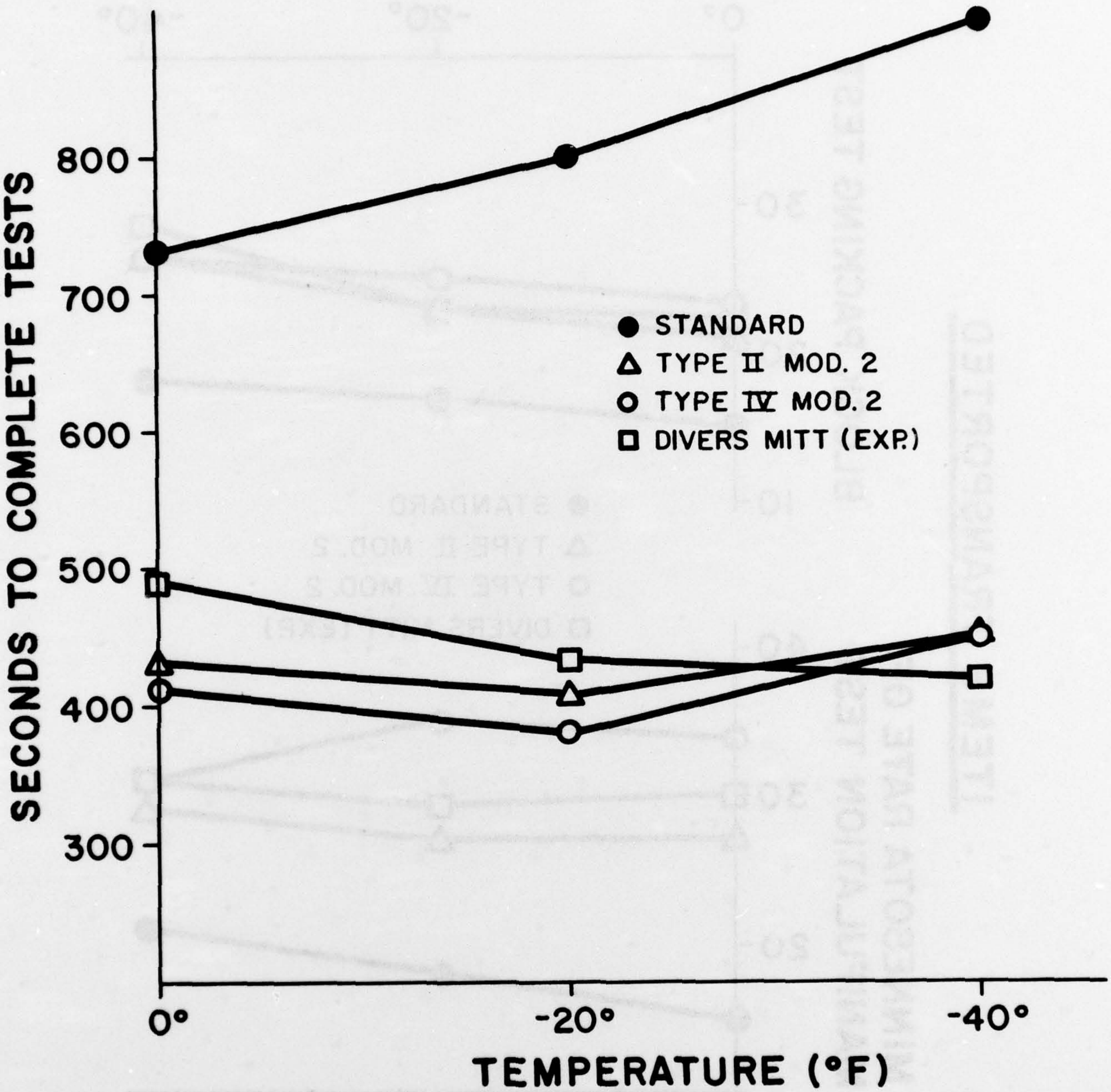

Figure 12. Performance in Hand-Tool Dexterity Tests.

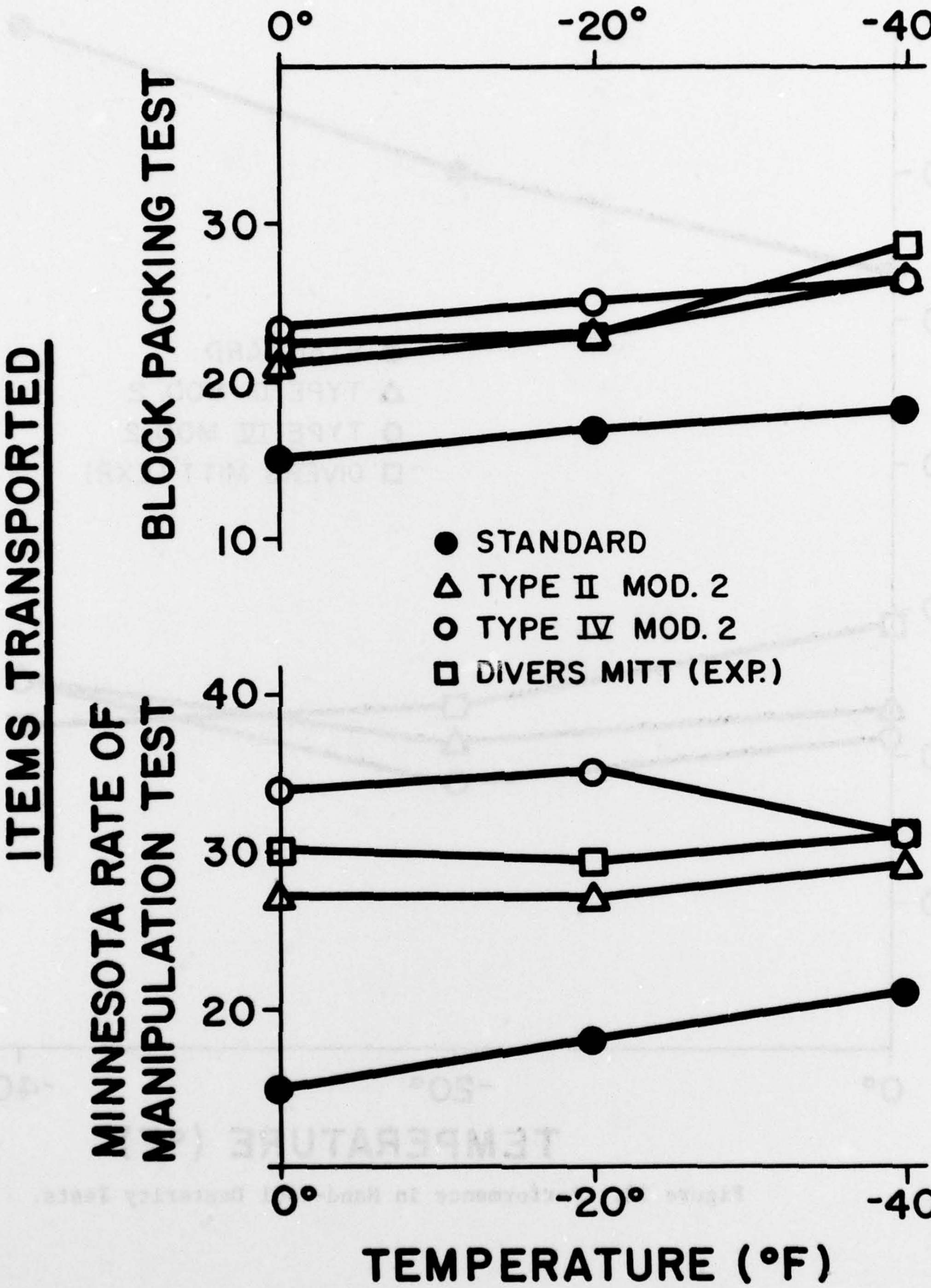

Figure 13. Items Transported in Minnesota Rate of Manipulation Test and Block Packing Test.

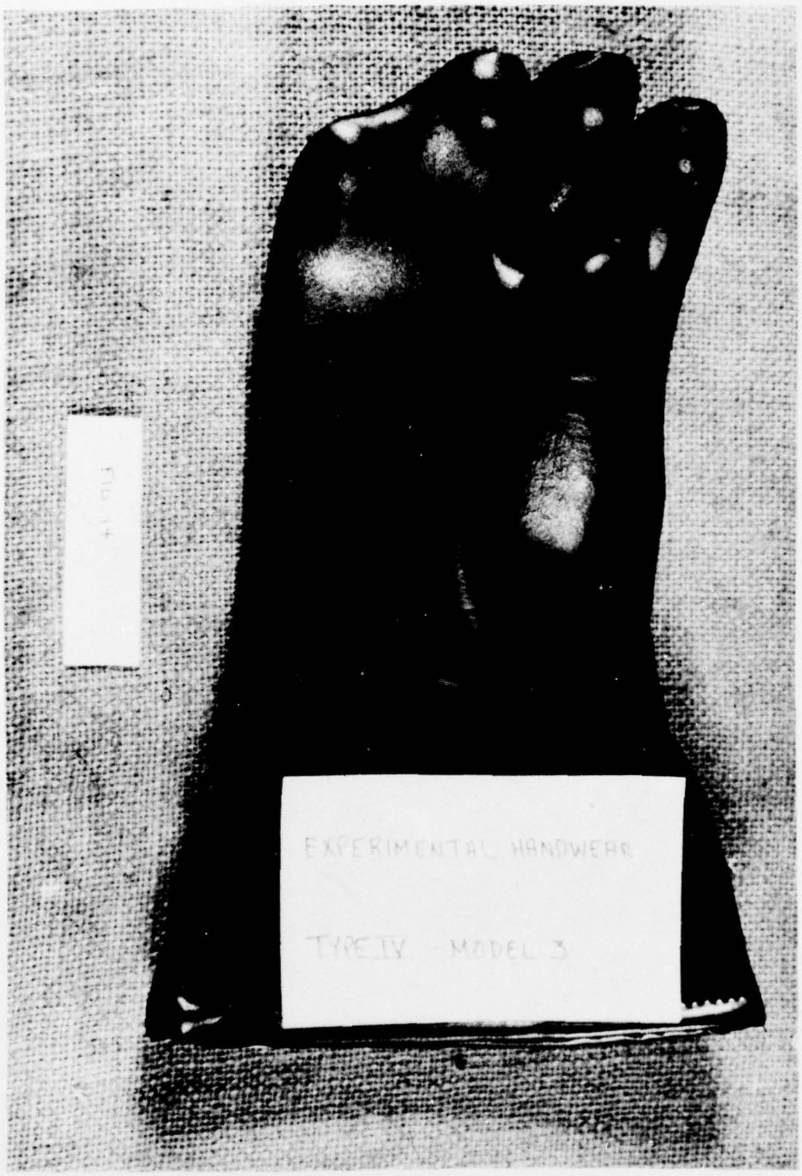

Figure 14. Experimental Handwear Type IV Mod 3.

APPENDIX B. REFERENCES

1. Gianola, S. V. and Reins, D. A., "Preliminary Studies on the Development and Testing of Low-Temperature Handwear With Improved Dexterity (Report No. 1)," NCTRF Report No. 106, December 1972.